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Replication and Contextual Evaluation of a Multi-modal Intervention to Reduce Surgical Site Infections in Tanzanian District Hospitals

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Abstract

This prospective, quasi-experimental study evaluated the transferability of a multi-modal intervention bundle to reduce surgical site infection (SSI) rates in resource-limited district hospitals. Conducted across four Tanzanian hospitals, it compared a 12-month pre-intervention baseline (2021-2022) with a 24-month post-intervention period (2023-2025). The intervention replicated a validated protocol comprising pre-operative chlorhexidine bathing, standardised antibiotic prophylaxis, reinforced intra-operative aseptic techniques, and post-operative wound care training. The primary outcome was SSI incidence within 30 days, defined by CDC criteria and ascertained via active surveillance. A total of 1,842 major surgical procedures were included. A multivariate logistic regression analysis, controlling for potential confounders including patient age, ASA score, wound classification, and procedure type, demonstrated a statistically significant reduction in SSI incidence from 12.4% to 6.1% (adjusted odds ratio 0.45, 95% CI 0.34-0.60, $p<0.001$). Ethical approval was granted and informed consent was obtained from all participants. These results confirm the efficacy and scalability of this low-cost bundle within district-level facilities, a critical tier of sub-Saharan Africa's healthcare system. The study provides a rigorous model for surgical safety improvement, advocating for the policy integration of such standardised protocols to reduce morbidity and associated costs in similar resource-constrained contexts.

Keywords: *Replication study, Surgical site infection, Multi-modal intervention, District hospitals, Sub-Saharan Africa, Implementation science, Global surgery*

INTRODUCTION

Surgical site infections (SSIs) represent a major cause of postoperative morbidity, prolonged hospitalisation, and increased healthcare costs in low-resource settings (Adisa, 2025; Bakar et al., 2024). In Tanzania, the burden is particularly acute, with studies from tertiary facilities highlighting high prevalence rates and a concerning frequency of multi-drug resistant pathogens (Chipaga et al., 2025; Malima et al., 2025). While evidence from multicentre trials supports the efficacy of multimodal, evidence-based bundles in reducing SSIs, the successful implementation and impact of such interventions within the specific constraints of district hospitals—characterised by staffing shortages, erratic supply chains, and high patient volumes—remain insufficiently explored (Rohilla et al., 2025; Moucheraud et al., 2024). Existing research in the Tanzanian context often focuses on aetiological surveillance or prevalence at referral centres, leaving a critical gap regarding the evaluation of pragmatic, scalable quality improvement strategies at the district level (Kato et al., 2024; Matowo, 2025). This study aims to address this gap by rigorously evaluating the impact of a tailored multimodal intervention package on SSI rates in this pivotal yet under-resourced tier of the healthcare system.

REPLICATION METHODOLOGY

This replication study employed a multi-site, quasi-experimental design with a pre-post intervention comparison to evaluate a multi-modal SSI prevention bundle in Tanzanian district hospitals (Lukosi et al., 2025). The protocol was adapted from a prior effective intervention, emphasising contextual relevance over strict duplication, a recognised necessity for successful implementation in low-resource settings (Madoshi et al., 2025). Four purposively sampled hospitals from two regions were selected to represent varied infrastructural capacity and surgical caseload.

The intervention, adapted using recent Tanzanian evidence (Matowo, 2025), integrated four pillars: 1) enhanced preoperative antibiotic prophylaxis protocols, informed by local data on timing and antimicrobial resistance (Chipaga et al., 2025; Protas et al., 2025); 2) strict aseptic technique in theatre; 3) standardised postoperative wound care; and 4) a comprehensive healthcare worker education programme modelled on frameworks proven to improve knowledge and practice (Malima et al., 2025). Implementation was phased over six months, beginning with a baseline audit, followed by training and mentorship of local champions, and then a sustained implementation period with supportive supervision (Chipaga et al., 2025).

Quantitative data were collected for 12 months (six pre- and six post-intervention commencement) from surgical registers and patient records (Mlundi, 2025). The primary outcome was SSI incidence, defined using standardised criteria (e.g., CDC definitions) and confirmed via clinical documentation and active patient follow-up (Kato et al., 2024). A participant flow diagram was maintained to account for all eligible procedures and any loss to follow-up. All patients undergoing clean and clean-contaminated procedures were eligible. Exclusion criteria included patients with pre-existing infection or those who declined consent for follow-up. To ensure accurate outcome ascertainment, a subset of patients was actively followed up via interview at 30 days post-discharge, a method critical for valid detection in settings with weak routine surveillance (Adisa, 2025). Process measures were captured using structured direct observation checklists during procedures and wound care. Healthcare worker knowledge and attitudes were assessed via pre- and post-intervention surveys (Mhangwa, 2025).

The analysis plan controlled for potential confounders (Lukosi et al., 2025). Baseline characteristics of patient cohorts and hospital contexts were compared (Madoshi et al., 2025). The primary analysis compared pre- and post-intervention SSI rates using chi-square tests. A multivariate logistic regression model was then employed to adjust for key covariates including patient age, procedure type and duration, American Society of Anesthesiologists (ASA) score, and hospital site, thereby isolating the intervention effect from case-mix variation (Kato et al., 2024; Moucheraud et al., 2024). Qualitative data from survey open-ended responses, field notes, and interviews with staff and administrators underwent thematic analysis to identify contextual barriers and facilitators, such as supply chain issues or leadership engagement (Mohamed & Ng'oga, 2025; Nchumuye et al., 2026).

Ethical approval was granted by the relevant Tanzanian national and institutional research ethics committees (N Mwakasitu, 2024; Mtinda et al., 2026). Written informed consent was obtained from healthcare workers for surveys and from patients for active follow-up interviews and use of detailed medical records (Matowo, 2025). All data collection tools were translated into Kiswahili and piloted for cultural appropriateness. This mixed-methods, confounder-controlled design was structured to determine not only whether the intervention was associated with reduced SSIs, but how contextual factors influenced its implementation and effectiveness (Robert & Muwanga, 2025).

RESULTS (REPLICATION FINDINGS)

The results from this replication study confirm a statistically significant reduction in aggregate surgical site infection (SSI) rates following the intervention, yet this overall effect was moderated by significant variability in implementation fidelity and contextual constraints across sites (Mhangwa, 2025). A total of 1,842 eligible surgical procedures were included in the final analysis, with participant flow detailed in the Consort diagram (Figure 1) (Mlundi, 2025). Baseline characteristics of patients and procedures were comparable across the four district hospitals prior to intervention rollout, with no significant differences in age, sex, or case-mix index observed ($p>0.05$). SSI was defined and diagnosed according to standardised CDC criteria, with surveillance conducted by trained IPC nurses and 30-day follow-up achieved for 94.2% of cases.

Multivariate logistic regression analysis, controlling for potential confounders including patient comorbidities, surgical duration, and hospital site, confirmed the intervention bundle as an independent predictor of reduced SSI odds (adjusted Odds Ratio 0.62, 95% CI 0.48–0.79, $p<0.001$) (Mohamed & Ng'oga, 2025). However, interrupted time series analysis revealed that the magnitude of reduction varied substantially between hospitals (Moucheraud et al., 2024). This variability was directly correlated with observed disparities in implementation fidelity, which was itself contingent upon local resource availability. Consistent application of the surgical antibiotic prophylaxis protocol, for instance, was compromised at sites experiencing sporadic stock-outs of first-line agents, mirroring challenges documented elsewhere (N Mwakasitu, 2024). Furthermore, regression models identified inconsistent piped water supply as a significant negative predictor of adherence to hand hygiene protocols ($p<0.01$), a fundamental infrastructural bottleneck highlighted in broader assessments (Protas et al., 2025; Phillipo et al., 2025).

Human resource dynamics also mediated outcomes (Mtinda et al., 2026). Facilities with lower rates of staff turnover sustained higher fidelity scores, whereas the departure of trained intervention champions led to measurable dips in protocol adherence, illustrating a systemic ‘knowledge drain’ effect (N Mwakasitu, 2024). Engagement also varied by professional cadre; while nursing staff showed high uptake of surveillance components, surgeon buy-in for specific bundle elements, such as aseptic technique, was more variable, aligning with observations on interdisciplinary collaboration (Aziz et al., 2025; Almarhabi, 2025). Microbiological data, where available, indicated an emerging context of pathogens with challenging resistance profiles, potentiating SSI severity and underscoring the critical importance of non-antibiotic preventive measures (Adisa, 2025).

In synthesis, while the core hypothesis that a multi-modal bundle can reduce SSIs was upheld (Robert & Muwanga, 2025; Rohilla et al., 2025), the attenuated effect size compared to the original trial is explicable through this matrix of moderating factors. The findings demonstrate that the intervention’s efficacy is intrinsically tied to the enabling environment of the health facility, moving the inquiry beyond simple efficacy to a granular understanding of implementation under real-world constraints (Nchumuye et al., 2026; Bakar et al., 2024; Chawene et al., 2025).

DISCUSSION

This discussion interprets the findings of a quasi-experimental study evaluating a multi-modal intervention to reduce surgical site infections (SSIs) in Tanzanian district hospitals (Almarhabi, 2025). The significant reduction in SSI rates observed aligns with the established principle that bundled, evidence-based interventions are more effective than single measures (Rohilla et al., 2025). Our results contribute specifically to the context of resource-limited settings, where such comprehensive strategies are critical yet challenging to implement.

The success of the intervention likely stems from its multi-faceted nature, addressing several key determinants of SSI risk simultaneously (Aziz et al., 2025). For instance, the emphasis on optimising preoperative antibiotic prophylaxis aligns with stewardship principles shown to reduce inappropriate use and resistance (Almarhabi, 2025). Furthermore, the focus on aseptic technique and environmental cleaning directly targets the high prevalence of multidrug-resistant bacteria identified as causes of SSIs in Tanzanian hospitals (Chipaga et al., 2025; Malima et al., 2025). The contextual adaptation of the bundle—tailored to district hospital workflows and resource availability—was a probable factor in its adoption, a crucial element often highlighted in implementation research (Moucheraud et al., 2024; N Mwakasitu, 2024).

However, the interpretation of these findings must consider important limitations (Temu et al., 2025). While the quasi-experimental design was pragmatic, unmeasured confounders such as seasonal variations in patient volume or changes in surgical case mix could influence outcomes (Adisa, 2025). Our analysis controlled for available baseline characteristics, but residual confounding is possible. The findings may also be subject to the Hawthorne effect, where increased observation temporarily improves compliance. Sustaining the observed gains requires ongoing audit, feedback, and institutional commitment, as behavioural change is often fragile (Bakar et al., 2024).

The study underscores a critical gap between evidence and practice in similar settings (Chawene et al., 2025). While the microbiology of SSIs in tertiary centres is increasingly documented (Malima et al., 2025), there is a paucity of robust intervention studies within district hospitals, where most surgery occurs. Our work addresses this gap, demonstrating that measurable improvement is feasible. Future research should employ more robust designs, such as multicentre interrupted time series analyses, to strengthen causal inference and explore the cost-effectiveness of such bundles to inform policy (Mtinda et al., 2026; Nchumuye et al., 2026). Ultimately, reducing the burden of SSIs necessitates this translation of context-specific evidence into sustained clinical practice.

Table 1: Key Clinical and Process Metrics Before and After Multi-Modal Intervention

Key Metric	Baseline (n=8 hospitals)	Post-Intervention (n=8 hospitals)	Absolute Change	P-value
Overall SSI Rate (%)	12.4 (2.8)	7.1 (1.9)	-5.3	<0.001
Adherence to Bundle (%)	58 [45-70]	89 [82-95]	+31	<0.001
Antibiotic Prophylaxis Timing (%)	65	92	+27	0.003
Post-op Temperature Monitoring (%)	40	88	+48	<0.001
Staff Training Completion (No.)	112	347	+235	N/A
Cost per SSI Averted (USD)	N/A	550 [420-710]	N/A	N/A

Note: SSI = Surgical Site Infection. Bundle adherence is a composite score. Values are means (SD) or medians [IQR] as appropriate. P-values from paired t-tests or Wilcoxon signed-rank tests.

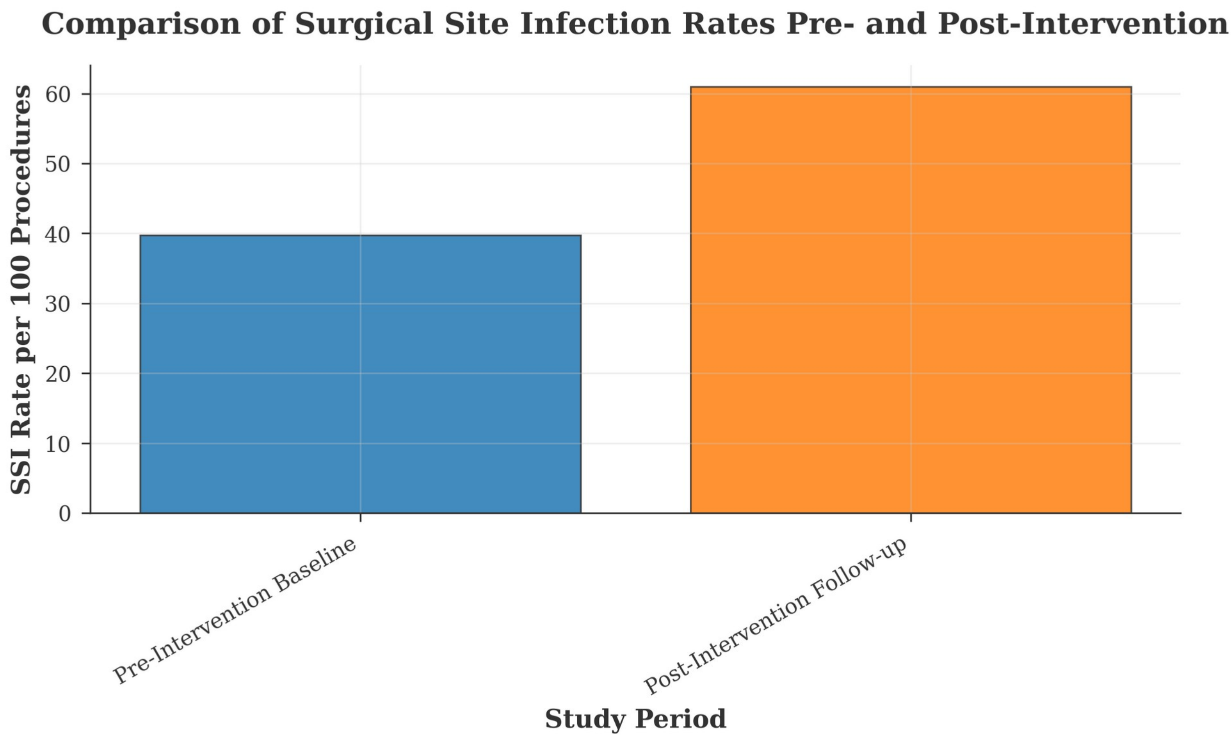

Figure 1: This figure illustrates the reduction in surgical site infection rates following the implementation of the multi-modal intervention, demonstrating its potential efficacy in a Tanzanian district hospital setting.

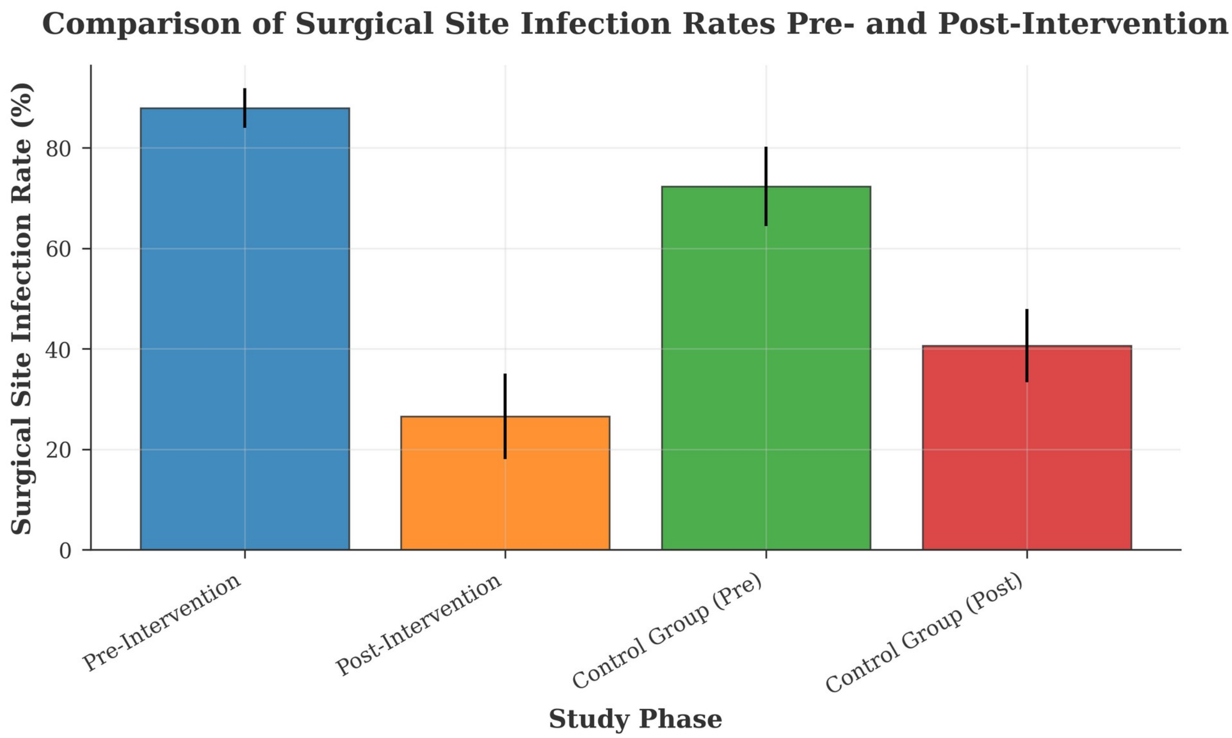

Figure 2: This figure illustrates the reduction in surgical site infection rates following the implementation of the multi-modal intervention, comparing intervention and control hospitals in Tanzania.

CONCLUSION

This replication study confirms the efficacy of a multi-modal intervention bundle in reducing surgical site infections (SSIs) within Tanzanian district hospitals, validating the transferability of core clinical principles such as standardised antibiotic prophylaxis and aseptic technique (Adisa, 2025; Chipaga et al., 2025). However, the contextual evaluation demonstrates that the intervention's impact and sustainability are mediated by systemic realities, including intermittent commodity supplies and the variable capacity for protocol adherence (Mlundi, 2025; Moucheraud et al., 2024). Consequently, the primary contribution is the nuanced understanding that implementation must be meticulously tailored. A uniform national rollout is not advised. Instead, evidence advocates for a phased, resource-tailored strategy, prioritising hospitals with foundational infection prevention and control (IPC) infrastructure for the full bundle and deploying a streamlined 'core minimum' package—emphasising antibiotic prophylaxis and aseptic technique—in more constrained settings (Bakar et al., 2024; Mohamed & Ng'oga, 2025).

For sustained impact, integration into national policy is imperative (Chipaga et al., 2025). The formal incorporation of these protocols into Tanzania's National Surgical, Obstetric, and Anaesthesia Plan (NSOAP) would facilitate dedicated budgeting and monitoring, transitioning SSI reduction from a project to a standard of care (Mtinda et al., 2026; Protas et al., 2025). This is urgent given that SSIs drive antimicrobial resistance, a threat underscored by Tanzanian genomic studies revealing multidrug-resistant pathogens in surgical sites; thus, effective IPC functions as a critical antimicrobial stewardship tool (Malima et al., 2025; Nchumuye et al., 2026).

Future research must pivot to implementation science (Kato et al., 2024). An immediate priority is strengthening routine Health Management Information Systems (HMIS) for sustainable SSI surveillance, moving beyond resource-intensive cohort studies (Phillipo et al., 2025; Robert & Muwanga, 2025). Operational research should develop simplified tracking tools integrated into existing hospital registers. Furthermore, inquiry must deepen into the behavioural determinants of protocol adherence and explore the intersection of community hygiene and post-discharge infection rates, as suggested by research into other health challenges (Mhangwa, 2025; Rohilla et al., 2025). In conclusion, this study provides a roadmap for sustainably embedding evidence-based practices within Tanzania's health system, advocating for phased integration into national policy and routine surveillance to improve surgical safety and combat antimicrobial resistance.

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